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TESTING SAFETY CATCHES ON MINE CAGES

LAKE SUPERIOR DISTRICT

BY

CLYDE M. PEARCE AND FRANK E. CASH

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

TESTING SAFETY CATCHES ON MINE CAGES LAKE SUPERIOR DISTRICT[1]

By Clyde M. Pearce[2] and Frank E. Cash[3]

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INTRODUCTION

The Lake Superior iron-mining district includes parts of the States of Michigan, Minnesota, and Wisconsin. The laws of each State provide for an industrial commission and for inspection of mines. The following extract from the General Orders on Mines, effective October 25, 1937, issued by the Industrial Commission of Wisconsin, is the only reference to the use of safety catches on mine cages or skips found in the laws and regulations in the Lake Superior iron-mining district:

> Order 316 - Cages for Hoisting Men.
>
> (c) Sides, Gates, and Safety Catches.
> ***Every cage shall be provided with safety catches of sufficient strength to hold the cage with its maximum load at any point in the event the hoisting cable should break.
> (d) Testing Safety Catches.
> The safety catches of cages and skips used to hoist men shall be kept well oiled and in good working order. They shall be tested at least once each month by tying up the cage or skip with hemp rope, lowering a few feet of hoisting cable on top of cage, then cutting the hemp rope, provided that any other system of testing, which is equally effective, may be used.

The general practice in the iron mines of the Lake Superior district is to provide cages wherein men maybe transported into and out of the underground workings. Riding in skips or on the bail of skips is prohibited. Men use ladders to go into and out of shallow mines, including one mine where the shaft is 315 feet deep from the collar to the floor of the station. Single- and double-deck enclosed cages varying in capacity from those capable of carrying 12 men to those carrying 90 men (with the two decks loaded) are used for handling both men and supplies. Doors or gates are provided, and the safety rules specify that these be kept closed when men are being transported. The cages are equipped with safety catches. The shaft area is small in some mines, and the cages and skips are hung in tandem, the skips being suspended under the cages; but this is unusual, as two skipways and one cageway generally are provided. The two skips are operated in balance, and the cage is usually in balance with a counterweight.

Types and sizes of hoists vary widely with depth of shafts and tonnages of ore produced. The single-drum hoist, with the hoisting ropes anchored at

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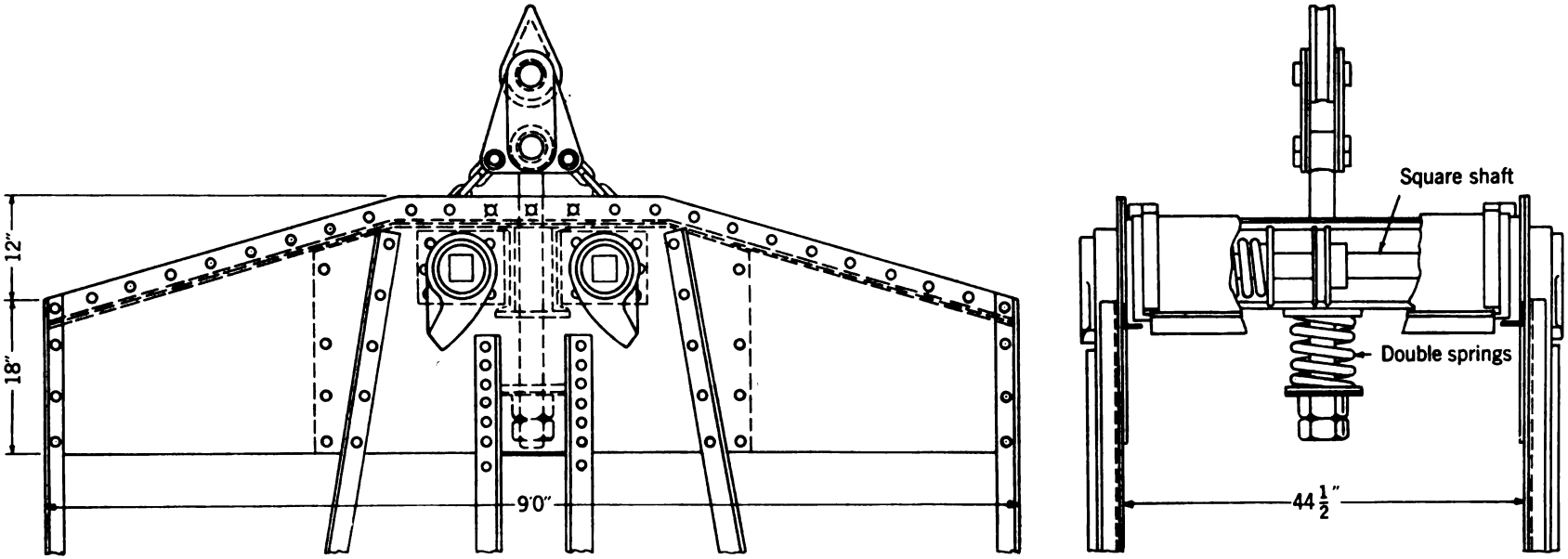

FIGURE 1.- Top of man cage showing safety catches.

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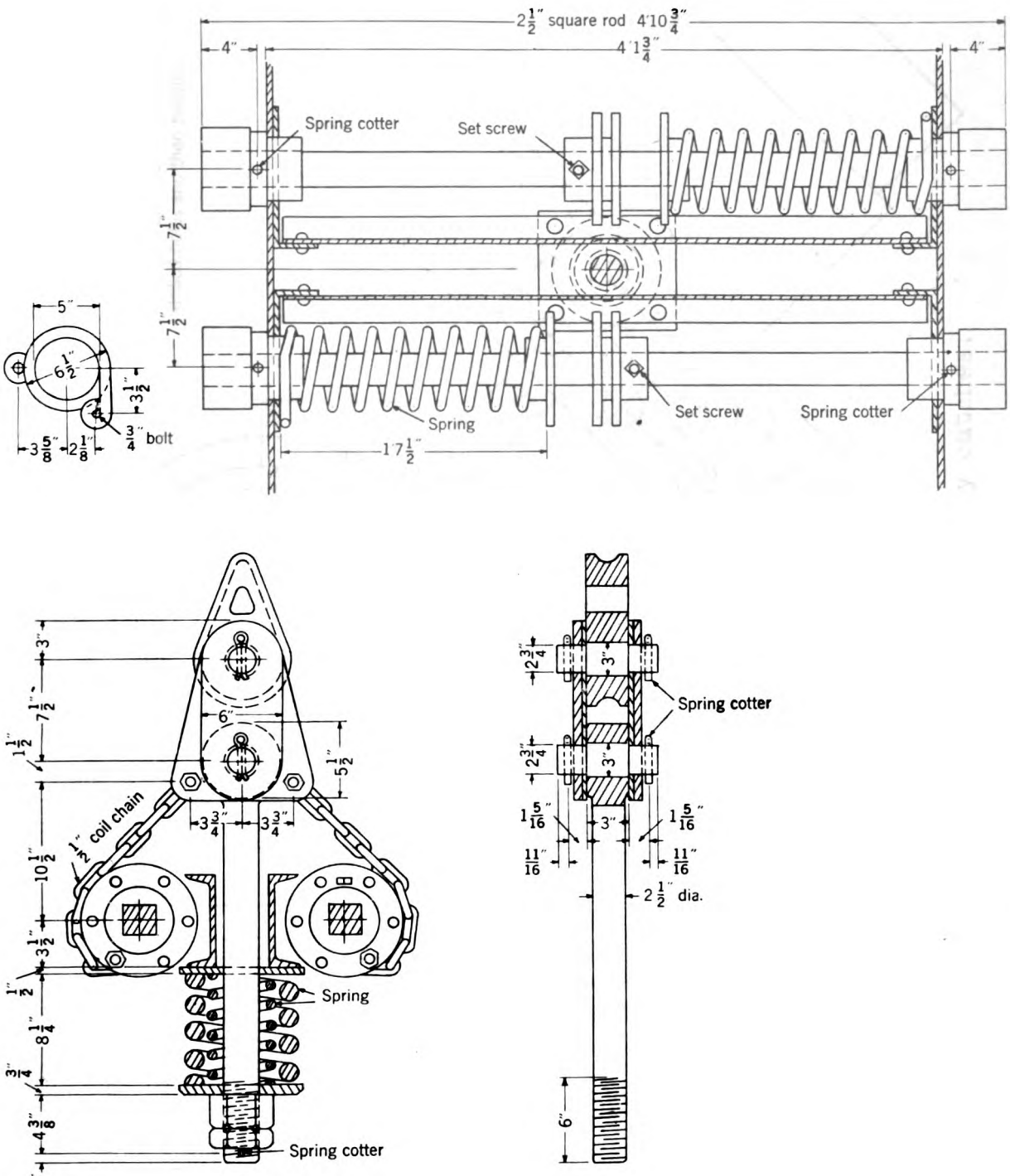

FIGURE 2.- Cage hanger and safety-catch assembly.

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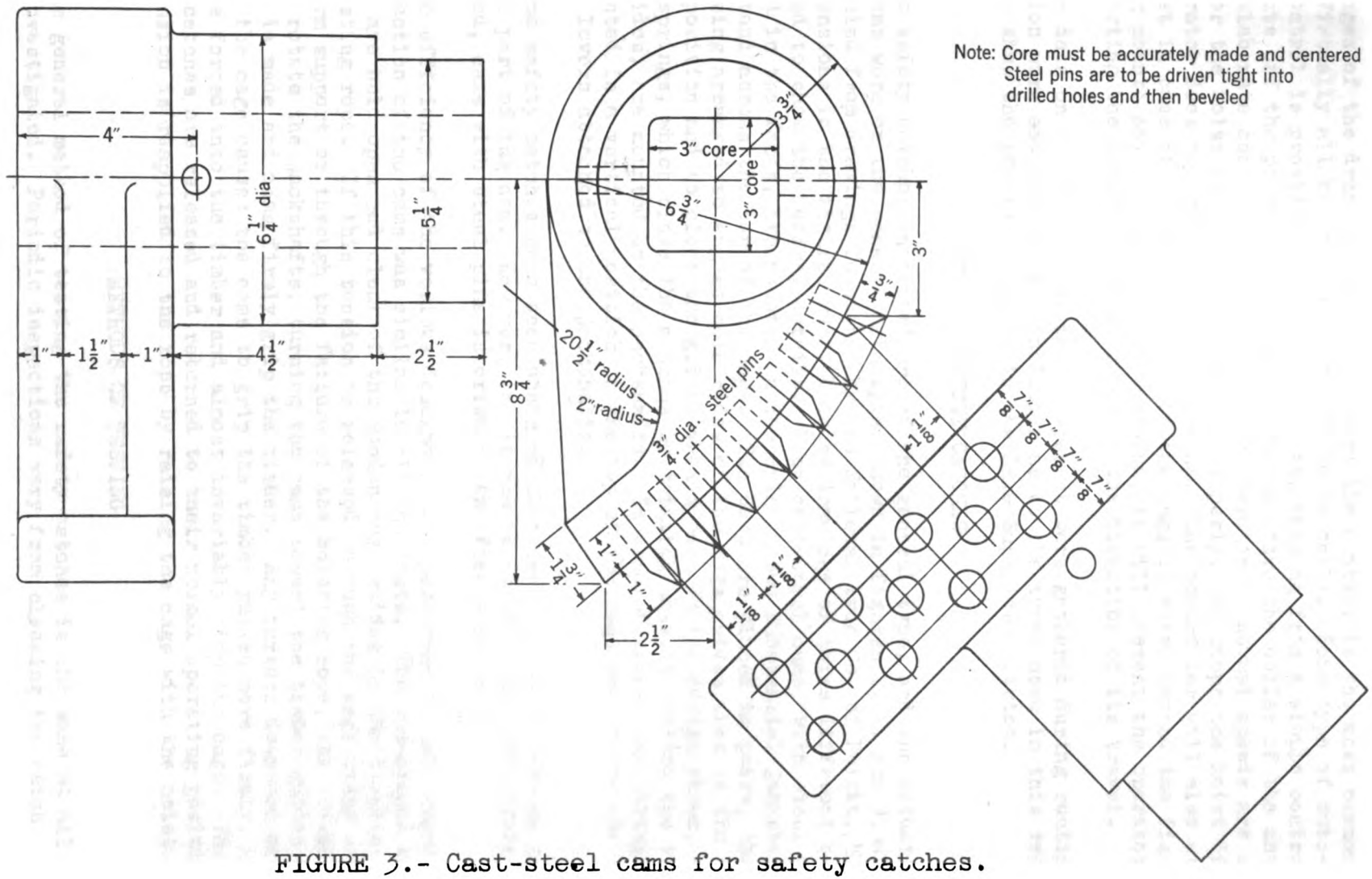

FIGURE 3.- Cast-steel cams for safety catches.

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the flanges of the drum and spooling toward the center, is the most common type. Virtually all hoists are operated electrically. Some type of automatic control is provided on all cage hoists, varying from a simple controller that shuts off the power if the cage is raised above the collar of the shaft to the elaborate controller that warms the operator if normal speeds are exceeded or the hoist is not being retarded properly, and stops the hoist if the operator does not respond to the warning. The controller will also stop the hoist in case of power failure or if the cage is moved beyond the fixed stopping point; and in the event of overwind, it will prevent the operator from starting the hoist before he reverses the direction of its travel.

The data on safety catches in this report were gathered during routine inspection work and are not all inclusive as to the types used in this region but they show the general practice in the Lake Superior district.

TYPES OF SAFETY CATCHES

The safety catches inspected are of the general type, and the actuating mechanisms work on the general principle, shown in figures 1, 2, and 3, which were copied from drawings furnished by the National Iron Co. of Duluth, Minn. The dimensions in the figures vary, because drawings of three different cages were used to show the desired details. Four cast-steel cams, with steel pins inserted in the faces, are mounted on the ends of two substantial jackshafts that extend across the top of the cage. The cams are placed in pairs, the pairs being arranged to engage both sides of the cage guides when in the closed position and to clear the guides when open. In the design shown, the coiled springs, which close the catches by rotating them to contact the wooden cage guides, are mounted on the jackshafts. In other designs, the springs are mounted in a vertical position on the top of the cage and rotate the cams through levers attached to the jackshafts.

Some safety catches have been designed that have the teeth cast as an integral part of the cam. However, in all the tests witnessed and herein described, cams with steel pins inserted in the face were used.

The efficiency of the various designs is not pertinent to this report, as the action of the cams was similar in all the tests. The cam-shaped safety catches are held open and clear of the wooden cage guides by the tension on the hoisting rope. If this tension is released through the cage being set on some firm support or through the failure of the hoisting rope, the coiled springs rotate the jackshafts, turning the cams toward the timber guides until contact is made and cams firmly grip the timber. Any further downward movement of the cage causes the cams to grip the timber guides more firmly, until they are forced into the timber and almost invariably stop the cage. The safety catches are released and returned to their normal operating position, when tension is reapplied to the rope by raising the cage with the hoist.

METHODS OF TESTING

The general method of testing the safety catches is the same at all mines investigated. Periodic inspections vary from cleaning the catch

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mechanisms once a month to a thorough daily inspection with the cage resting on chairs, and the testing of the action of the catch-actuating mechanism by releasing and reapplying the tension on the hoisting rope. A drop test, with a written report of the results achieved, is made every month. Methods of testing vary, but in every test the cage is suspended from some device attached to its drawbar, and, when the suspending device is released, the freed cage is allowed to drop until it is stopped and held by the safety catches.

Most of the tests are made with an empty cage. Many of the mine officials said tests show that the reaction of the safety catches is the same when the cage is empty as when it carries a dead load; therefore, the empty cage is used for convenience.

It is worthy of note that in seven of the thirteen tests observed, the safety catches were not disturbed before the test was made. In the other six instances, the cage was lowered onto rests, and the tension on the hoisting rope was released during the process of installing the testing device. At one mine, the only inspection is made during the monthly drop test, when the cage is rested on timbers at the collar of the shaft both before and after the test to facilitate cleaning and oiling of the safety-catch mechanism. As it is the usual practice to release the tension on the hoisting rope by pulling slack in it and forming a loop around the tripping device rather than by disconnecting it from the cage, this method is referred to as the "slack-rope drop test" in this report.

Another interesting practice is the provision of short, easily replaceable sections in the wooden cage guides at the point where the cams engage in testing. The tests are conducted just above the collar of the shaft, and blocking is placed across the collar to prevent the cage from dropping down the shaft should the catches fail. There have been occasional failures, but these were due to improper maintenance, such as allowing ice or other foreign material to accumulate in the actuating mechanism.

TEST OF SAFETY CATCHES

Mine A

Mine A has a daily production of approximately 2,200 long tons of iron ore, which is hoisted from a depth of 3,600 feet in two 9-ton-capacity skips operated in balance. One double-deck cage, balanced with a counterweight, is provided for the transportation of the 218 underground employees and mine supplies. Both the skip and cage hoists are equipped with Lilly controllers as protection against overspeed and overwind.

The cage is equipped with cam-type safety catches, which are normally held open by the tension on the hoisting rope. When the tension is released, the cams are rotated by springs that force the teeth against the wooden cage guides. The safety catches are inspected daily by noting the action of the mechanism as the cage is placed on chairs at the collar of the shaft. They are tested each month by the slack-rope drop test.

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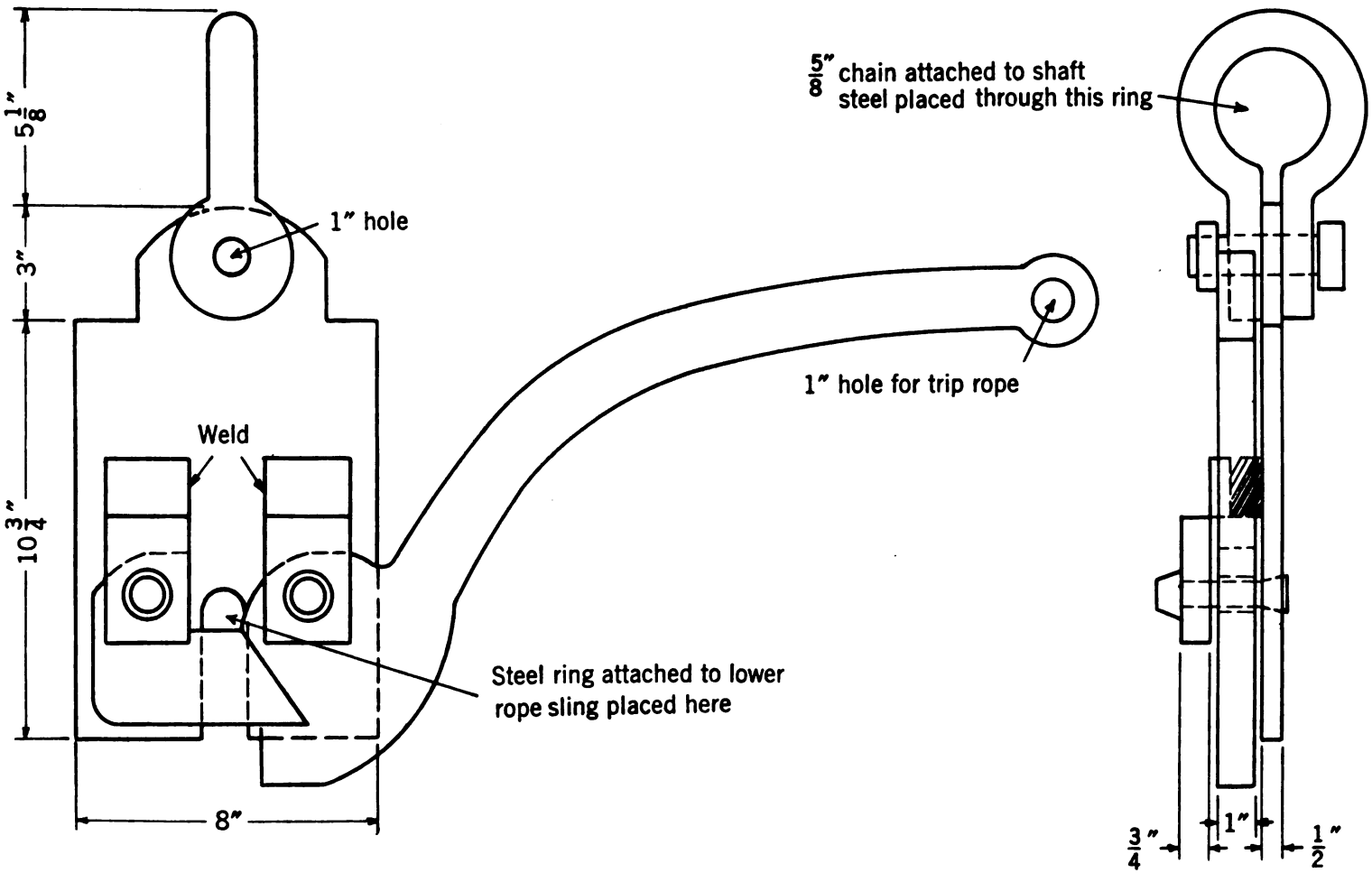

FIGURE 4.- Tripping device for testing safety catches—mine A.

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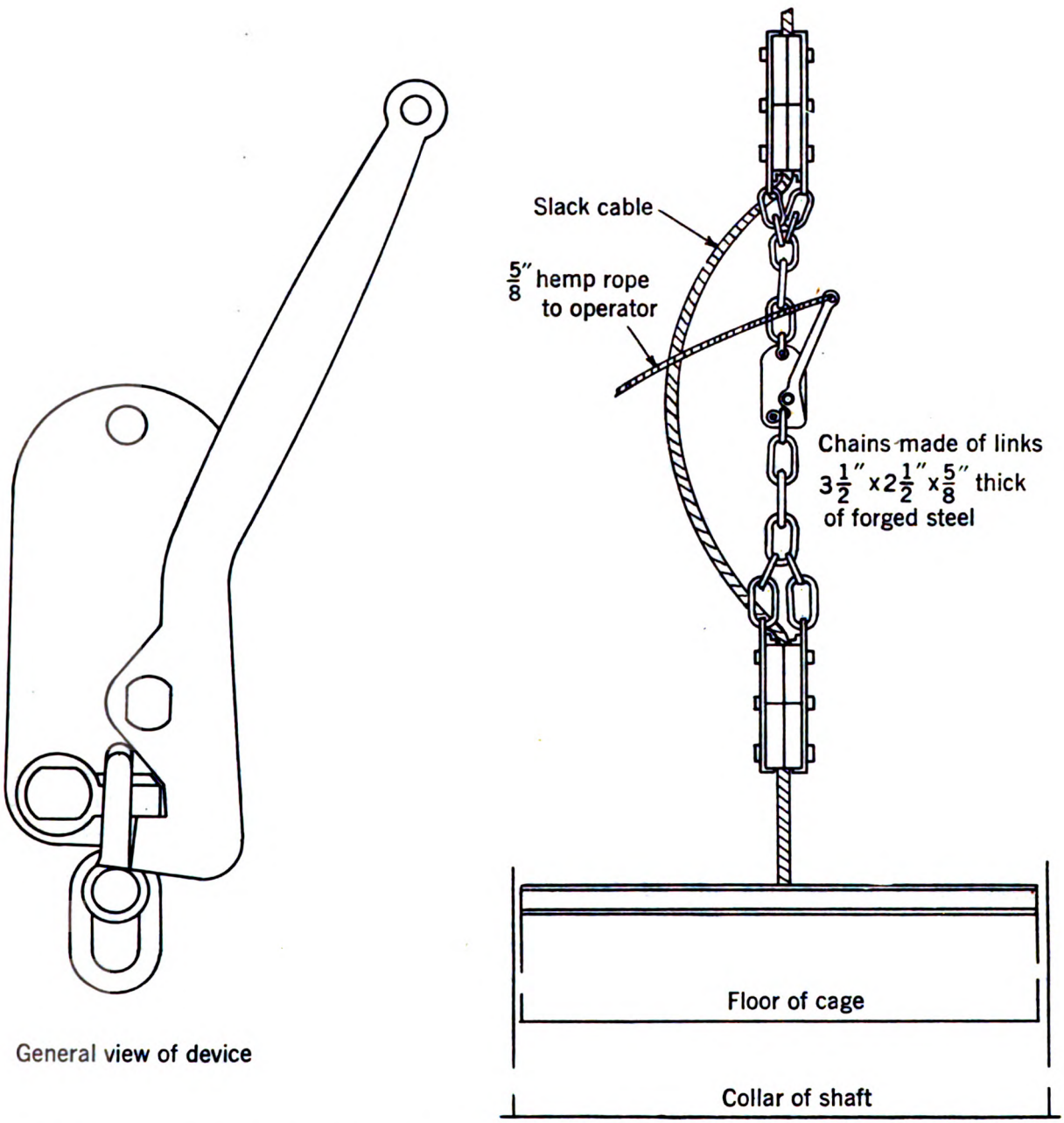
Slack cable
5/8" hemp rope to operator
Chains made of links 3 1/2" x 2 1/2" x 5/8" thick of forged steel
Floor of cage
Collar of shaft
General view of device

FIGURE 5.- General arrangement of device for testing safety catches—mine B.

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When the safety catches are to be tested, the cage is hoisted into the headframe, the shaft opening is covered by steel fire doors, and two 6-inch steel H-beams are placed over the doors for greater strength. Two steel-rope slings are fastened to the hoisting rope, one about 4 feet and the other about 20 feet above the cage. A 3/8-inch steel cable with 3/4-inch block and tackle attached is fastened to the upper sling to pull slack in the hoisting rope. A steel ring is provided on the lower sling for attaching the lower end of the tripping device, which is illustrated in figure 4. The upper end of the device is fastened to a 5/8-inch steel chain, which is attached to and supported by members of the steel headframe. When the tripping device is in place, the cage is lowered until its weight is supported by the tripping device. About 1-1/2 feet of slack is then pulled in the hoisting rope, the tripping device is sprung, and the freed cage drops until the safety catches function. If the cage drops more than 3 inches, the safety catches are adjusted, and the test is repeated until the drop is 3 inches or less.

Mine B

Mine B has three shafts ranging in depth from 2,700 to 3,200 feet; one is vertical, and the other two are inclined about 67 degrees. The output of 4,600 long tons of iron ore produced each day is hoisted in skips in the vertical shaft. All three shafts are equipped with cages, which are used for the transportation of supplies and the 470 underground employees. The hoists are equipped with Lilly controllers for protection against overspeed and overwind. The cages are equipped with cam-type safety catches, which are normally held open by the tension on the hoisting ropes. When the tension is released, the catches are rotated by springs in the actuating mechanism, and the teeth on the cams are forced against the wooden cage guides.

The safety catches are inspected daily by a mechanic, who rides on the bonnets of the cages as they are lowered onto the cage chairs at the collars of the shafts and watches the action of the mechanisms. Any imperfection is corrected without delay.

The safety catches are tested each month by the slack-rope drop tests. When a test is to be made, the cage is hoisted above the collar of the shaft, two tiers of four 3- by 12-inch planks are placed across the shaft, one on each side, and the cage is lowered onto these planks. Two clamps that support the testing device, illustrated in figure 5, are attached to the hoisting rope, one just above and the other about 30 feet above the cage; slack is pulled by means of a hand line attached to the upper clamp; and the lower chain of the testing device is attached to the tripping device, which is suspended from the upper clamp, forming a loop in the hoisting rope. The cage is then suspended from the testing device by hoisting it 1 to 4 feet above the blocking across the collar of the shaft. When the arrangements have been completed, the tripping device is sprung, and the freed cage drops until it is stopped by the safety catches. If the drop exceeds 3-1/2 inches, the safety catches are checked and put in proper working order. The cage is spotted for each test so that the cams of the safety catches will engage undamaged places on the removable sections of the wooden cage guides.

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Mine C

The three-compartment shaft, 1,900 feet deep, inclined at 78 degrees, limits the productive capacity of mine C. Two compartments are used for hoisting the 800 long tons of iron ore produced each day and for transporting the 280 underground employees and the mine supplies. The skips are suspended under the cages, and the skip-cage units are operated in balance. The hoist is equipped with a Lilly controller for protection against overspeed and overwind, which is quickly and easily adjusted to permit high speed for hoisting ore and low speed for hoisting men. The cages are equipped with cam-type safety catches, which are normally held open by the tension on the hoisting rope. When this tension is released, springs rotate the safety catches, forcing the toothed faces of the cams against the wooden cage guides.

The safety catches are inspected three times each week and are tested by the slack-rope drop-test method once each month. When the test is to be made, the skip-cage unit is hoisted into the head frame, and two 12- by 12-inch timbers are placed across the shaft at the collar. A testing device is then suspended in the head frame and fastened to the hoisting-rope thimble at the top of the cage. The unit is then lowered until it is supported by the testing device, and enough slack is obtained to insure that it will drop to the 12- by 12-inch timbers if the safety catches fail. The testing device is then sprung, and the unit, freed of support, drops until it is stopped by the safety catches. If the drop is more than 4 inches, the safety-catch mechanism is examined and put in proper working order.

Mine D

Mine D is operated by open-pit mining methods except for the final transportation of the ore and employees. The ore is transported from the open pit to the shaft pocket by means of a series of belt conveyors and is then hoisted to the surface through the shaft. The four-compartment, 300-foot-deep shaft is equipped with two skips for hoisting ore and a cage for the transportation of men and supplies. The output of about 6,000 long tons of iron ore is hoisted daily by operating the skips 16 hours a day.

The cage is equipped with cam-type safety catches, which are normally held open by the tension on the hoisting rope. When the tension is released, springs in the actuating mechanism force the teeth of the cams against the wooden cage guides. The safety catches are tested monthly by the slack-rope drop-test method. When the drop test is to be made, the cage is hoisted into the head frame, and two 40-pound rails are placed across the shaft at the collar. The cage is lowered onto the rails, and enough slack is pulled in the hoisting rope to permit connecting the tripping device, which is permanently attached to the hoisting rope. When the testing device is in place (fig. 6), the cage is hoisted until it is suspended, from the device, about 3 feet above the rails; the device is sprung, and the cage, freed of support, drops until it is stopped by the safety catches. If the drop is 3 inches or less, the safety catches are considered to be working properly.

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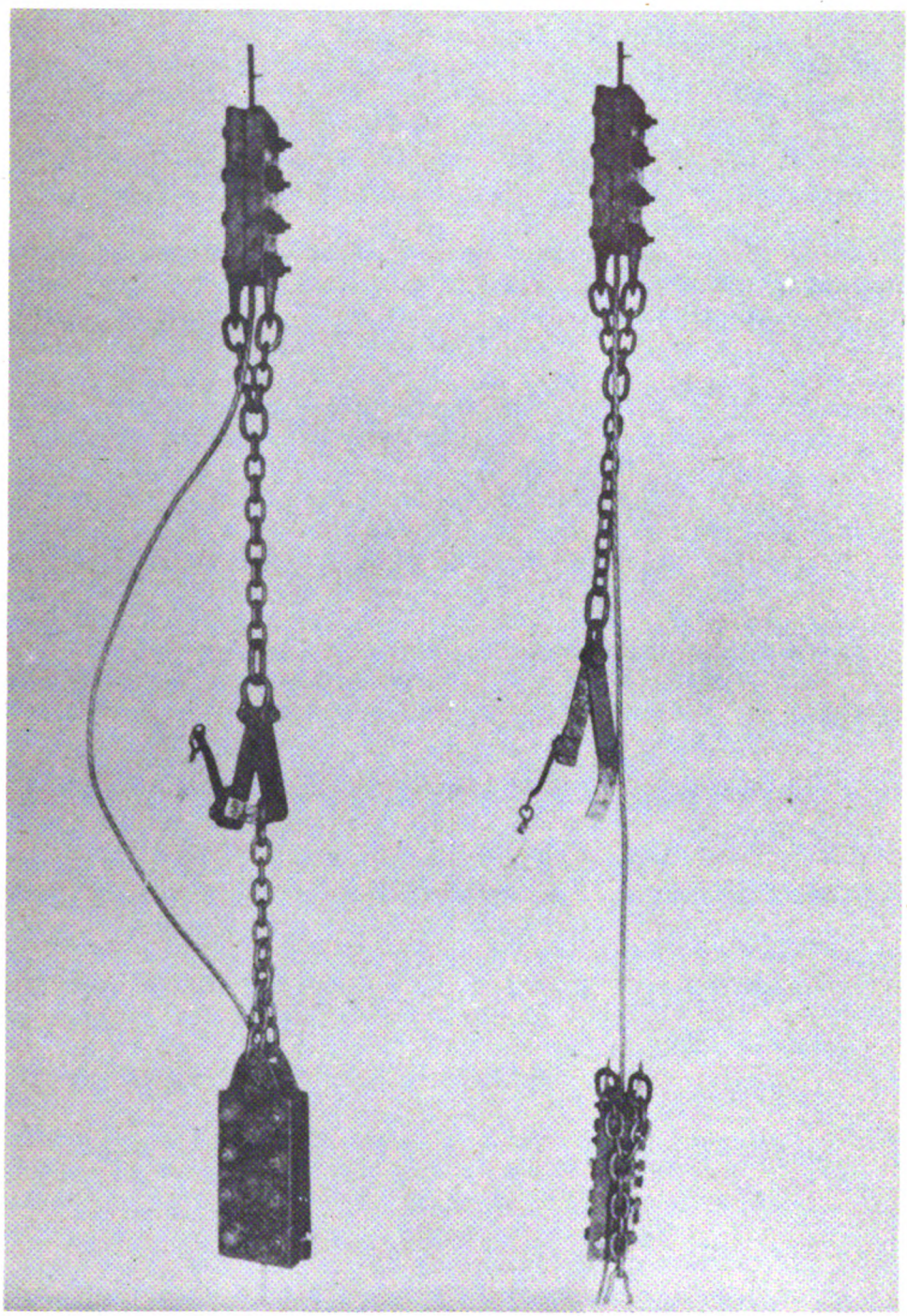

FIGURE 6.- Testing device for safety catches, before and after tripping—mine D.

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Mine E

The 348-foot deep shaft at mine E is equipped with two skips and a cage. Daily production is about 1,000 long tons of iron ore, and 80 men are employed underground. The cage is unique in the Lake Superior district, as it is normally operated as an elevator by the skip rider. It can be operated in the usual manner by switching the control to the hoistman. Interlocking switches prevent simultaneous operation of the two controls.

The method of making the monthly drop test of the safety catches is similar to that used in other mines in the district, but the place where the test is made is unusual. When the drop test is to be made, the cage is hoisted into the head frame, a 12- by 12-inch timber is placed across the shaft at the collar, and the cage is lowered onto the timber. Boards are laid on the ground between the hoist house and the first idler stand, and enough slack is pulled in the hoisting rope to cause it to lie on the boards. Two steel plates with Crosby clips are fastened to the hoisting rope where it is lying on the boards, and the testing device is attached to these plates so that a 15-foot loop is formed in the rope. The hoist is then started, and the cage, supported by the testing device, is raised about 10 feet above the 12- by 12-inch timber. The testing device is sprung by means of a trigger and rope, and the cage, freed of support, drops until the safety catches function. The cage dropped less than 5 inches at the time the test was observed. The testing device was disconnected, splinters of wood were removed from the cams, and the cage was returned to its normal operation.

Mine F

The four-compartment, 345-foot-deep shaft at mine F is equipped with two skips that operate in balance and a service cage that is used for the transportation of men and supplies. The hoists are equipped with Lilly controllers. The cage is equipped with cam-type safety catches, which are normally held open by the tension on the hoisting rope. When the tension is released, springs rotate the safety catches, forcing the teeth of the cams against the timber cage guides. The safety catches are tested once each month by the slack-rope, drop-test method.

When the drop test is to be made, the cage is hoisted into the head frame, and heavy timbers are placed across the shaft at the collar. The cage is lowered onto these timbers, slack is pulled, and a loop is formed in the hoisting rope by fastening a piece of hemp rope to the drawbar of the cage above the safety catches and to the hoisting rope above the looped section. The cage is then hoisted a short distance above the timbers to suspend it on the hemp rope and complete preparations for the test. The hemp rope is then severed with an ax, and the freed cage drops until it is stopped by the functioning of the safety catches. It is reported that the catches have always stopped the cage and that the drop is 2 to 3 inches.

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Mine G

Production at mine G is about 2,000 long tons of iron ore a day, with 324 employees working underground. Four vertical shafts are in use, but only two, one about 2,200-feet and the other 1,200-feet deep, are used for the transportation of men and supplies. The hoists are equipped with automatic controllers for protection against overspeed and overwind. The ore is hoisted in skips, and men and supplies are transported in cages. The cages are equipped with safety catches, which are tested by dropping a short distance once each month.

When the safety catches are to be tested, the cage is hoisted into the head frame, two 12- by 12-inch timbers are placed across the shaft at the collar, and the cage is lowered onto the timbers. The hoisting rope is disconnected from the cage, and a tripping device, shown in figure 7, is installed between it and the cage. The cage is hoisted a few feet above the timbers, the tripping device is sprung, and the freed cage falls until the safety catches function. According to report, the distance dropped varies from 2 to 4 inches, depending on the condition of the wooden cage guides. About 20 minutes are required to make the test.

Mine H

The four-compartment shaft at mine H is 700 feet deep; two compartments are used for the skips and are operated in balance, one compartment is the ladder and pipeway, and the fourth compartment is the cageway. Average daily production is 400 long tons of iron ore, with 30 men employed underground. The hoists are equipped with Lilly controllers for protection against overwind. The cage is equipped with cam-type safety catches, which are normally held open and clear of the wooden cage guides by the tension on the hoisting rope. The safety catches are inspected every week, and they are tested by the slack-rope drop-test method every month.

When the safety catches are to be tested, the cage is hoisted into the head frame, and a piece of 12- by 12-inch timber is placed across the shaft at the collar. A piece of 6-inch steel pipe is placed across the cageway in the head frame above the cage; a chain is passed over the pipe and through a clevis attached to the drawbar of the cage, and the ends are fastened together by means of the tripping device illustrated in figure 8. The cage is lowered, until it is suspended on the tripping device, and enough slack is pulled in the hoisting rope to insure that it will drop to the timber across the collar if the safety catches fail. The tripping device is then sprung, and the freed cage falls until the safety catches function. It is reported that the catches have never failed to stop the cage, and that the maximum drop if 3-1/2 inches. The test had been made with a dead load on the cage, and the results were the same.

Mine I

The shaft, 2,100 feet deep at mine I has only two compartments, both of which are used for hoisting. The cages will hold a maximum of 12 men, and

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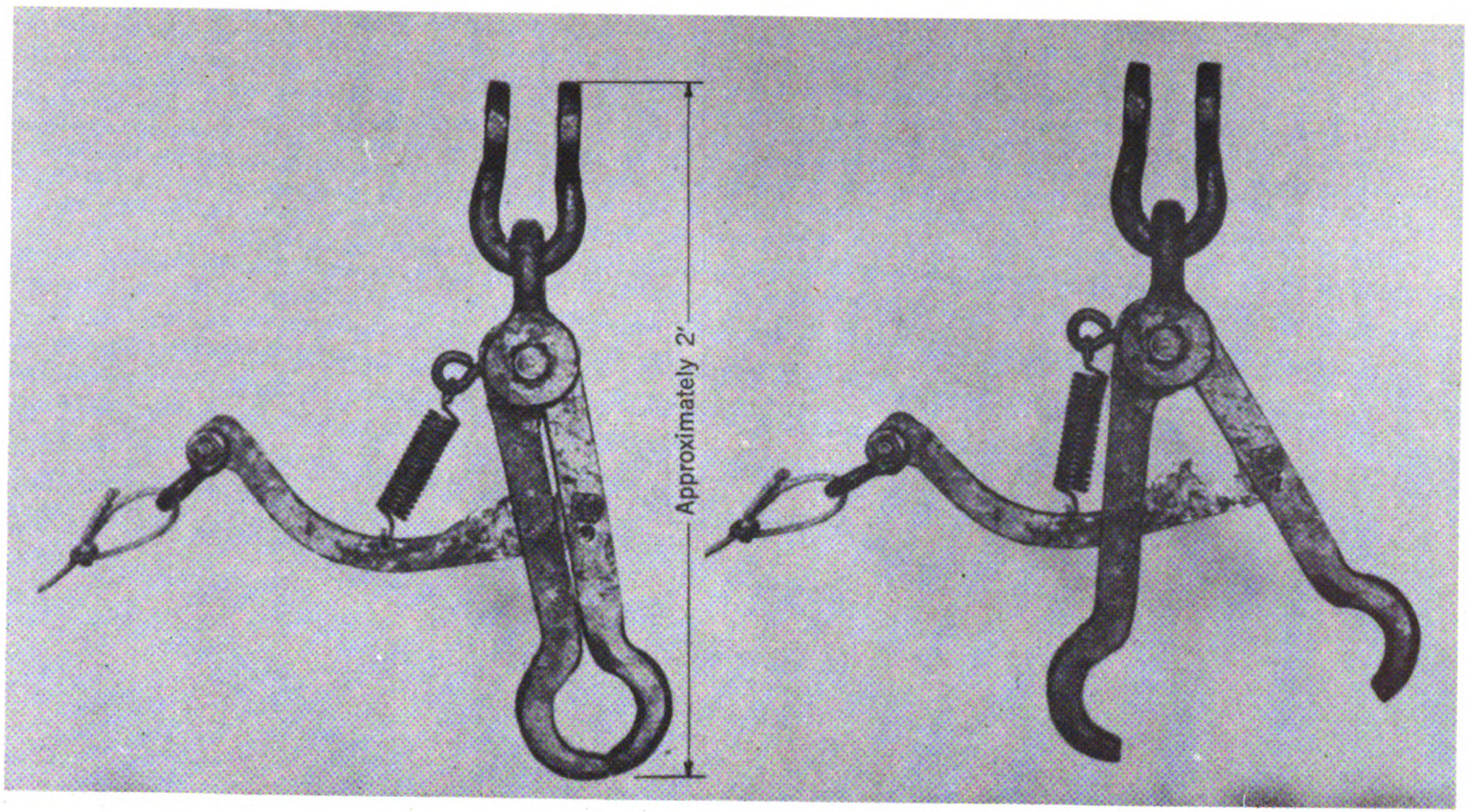

FIGURE 7.- Tripping device for testing safety catches—mine G.

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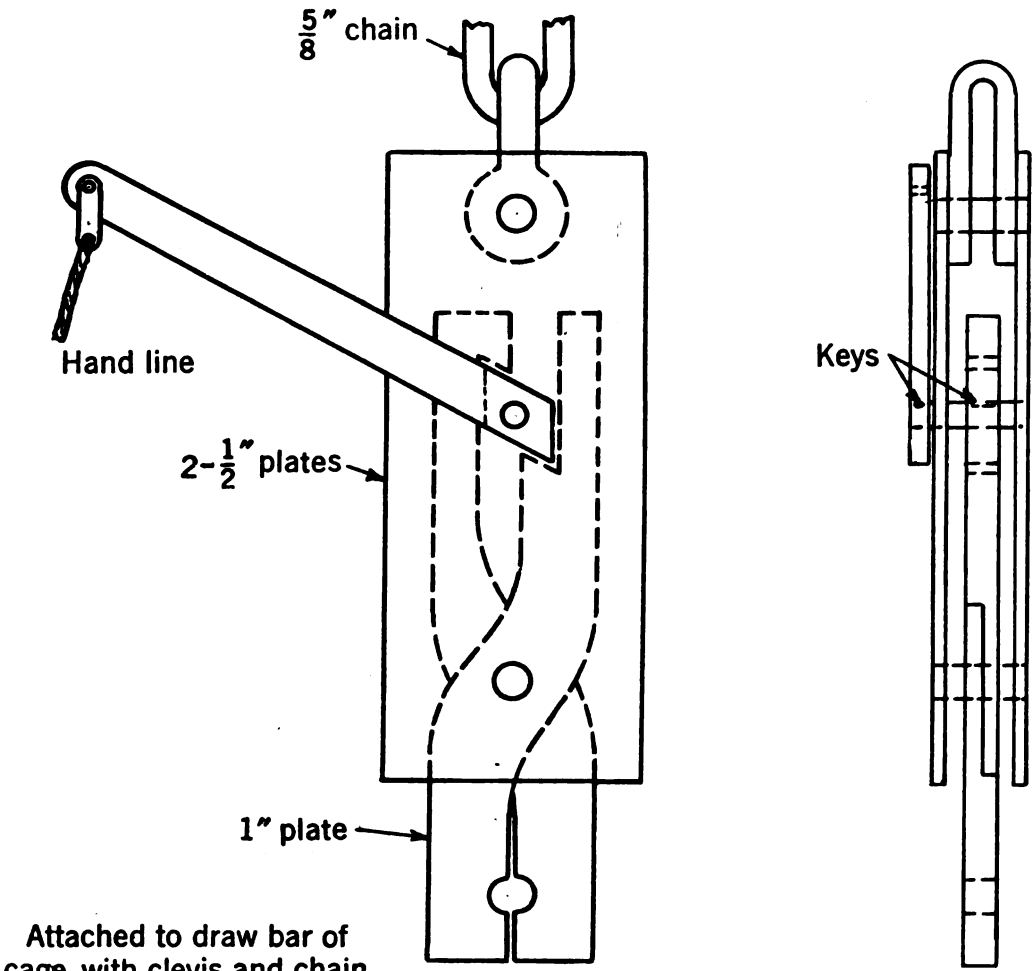

FIGURE 8.- Tripping device for testing safety catches—mine H.

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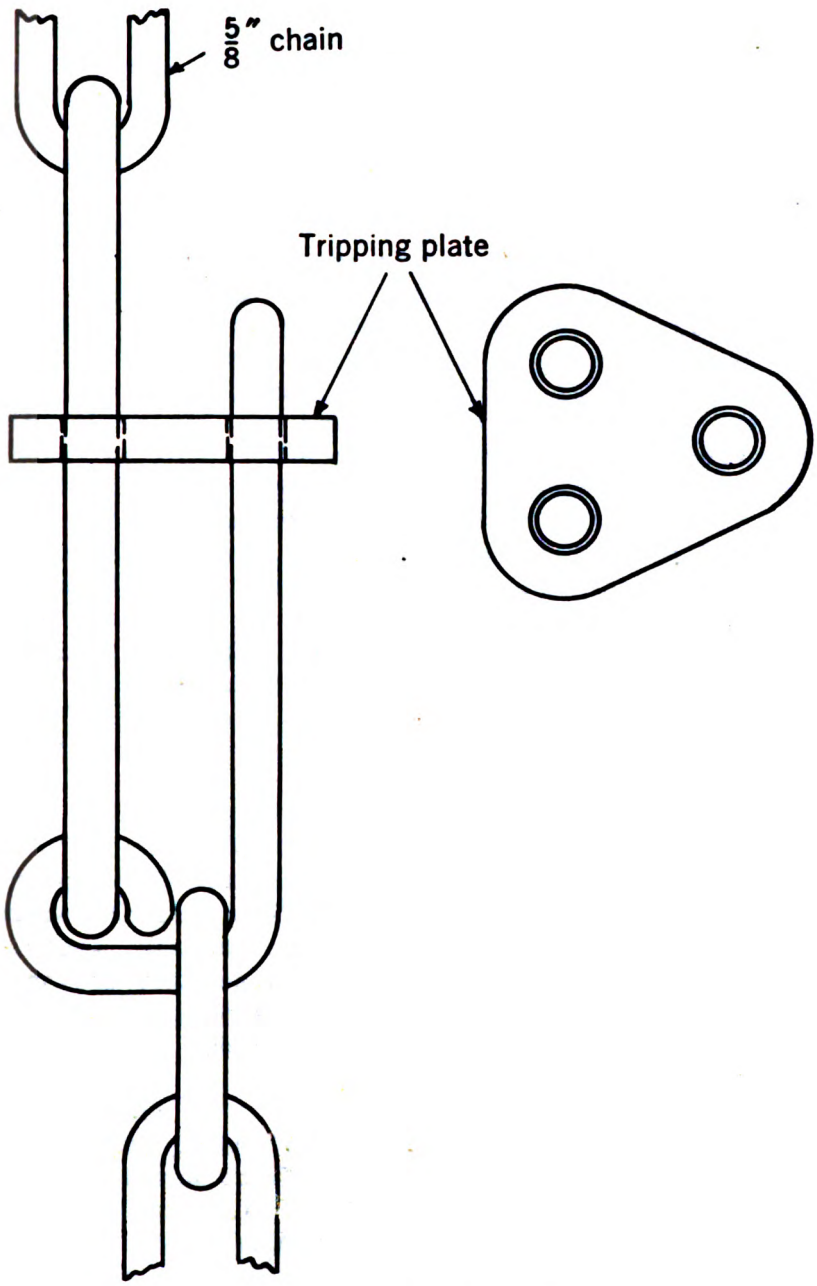

FIGURE 9.- Tripping device for testing safety catches—mine J.

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the skips, which are suspended under the cages, carry 4 tons of ore when loaded to capacity. An output of about 1,100 long tons of iron ore is produced daily by the 86 men employed underground. The skip-cage units, which weigh about 8 tons each, are operated in balance. The single-drum, electric-powered hoist is equipped with a Lilly controller for protection against overwind and overspeed. The cages are equipped with cam-type safety catches, which are normally held open and clear of the wooden guides by the tension on the hoisting rope. The safety catches are tested every month by the slack-rope, drop-test method.

When the drop test is to be made, the unit is hoisted into the head frame, and two 5-inch steel H-beams are placed across the shaft at the collar. An 8- by 10-inch timber is placed across the cageway in the head frame above the unit; a 5/8-inch chain is passed over it and through the thimble on the top of the cage, and the ends of the chain are fastened together with a tripping device, as shown in figure 8. The unit is then lowered until it is suspended by the chain and the tripping device, and 4 or 5 feet of slack is taken in the hoisting rope. The connecting chain is adjusted for each test so that the cam teeth will engage the wooden cage guides in an undamaged place. After the unit is in position for the test, timbers are placed on the H-beams across the shaft until they reach a point about 10 inches below the skip, to limit the fall of the unit if the safety catches fail. When the arrangements are complete, the tripping device is sprung by pulling the trigger with a hand line, and the freed unit drops until the safety catches function. It is reported that the catches have always stopped the unit after a maximum drop of 5 inches.

Mine J

An output of about 1,000 long tons of iron ore is produced daily from mine J by working two 8-hour shifts with a total of 75 underground employees. The ore is hoisted through a shaft about 450 feet deep by means of two skips working in balance. Men and supplies are transported in a cage equipped with cam-type safety catches normally held open by the tension on the hoisting rope. The safety catches are inspected weekly and are tested once each month by the slack-rope drop-test method.

When the drop test is to be made, the cage is hoisted into the head frame, a 3-inch wooden plank is placed across the shaft at the collar, and a 45-pound rail is placed on the plank. An oak railroad tie is placed in the head frame above the cage; a 5/8-inch chain is passed over the tie and through the clevis on the drawbar of the cage, and the two ends of the chain are fastened together by means of a tripping device, a sketch of which is shown in figure 9. The cage is lowered until it is supported by the chain and tripping device, and 5 or 6 feet of slack is pulled in the hoisting rope. When these arrangements have been completed, the triangular plate of the tripping device is driven upward with a hammer until the hook springs open, releasing the chain and freeing the cage, which drops until the safety catches function.

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Mine K

Mine K has two shafts, one vertical and one inclined, each about 3,000 feet deep. The vertical shaft is the production shaft and is equipped with two skips for hoisting ore and a cage for transporting men and supplies. The inclined shaft is used essentially for ventilation purposes but is equipped with a cage, as it is an emergency outlet from the mine. Daily production is about 2,800 long tons of iron ore, with 339 underground employees. The cage in the hoisting shaft will carry a maximum load of 90 men when both decks are loaded.

The two skips are operated in balance, and the cage is balanced with a counterweight. Each unit is handled with a single-drum hoist, which is safeguarded with a Lilly controller for protection against overspeed and overwind. The cages are equipped with cam-type safety catches, which are normally held open and clear of the wooden cage guides by the tension on the hoisting rope. The safety devices are inspected weekly, and they are tested each month by the slack-rope drop-test method.

Testing equipment is permanently installed in the head frame of the hoisting shaft, and a clevis is installed on the cage to facilitate the test. When the cage is to be tested, it is hoisted into the head frame, three 12- by 12-inch timbers are placed across the shaft at the collar, and a chain is installed between the tripping device (fig. 10) and the clevis on the cage. The cage is then lowered until it is supported by the testing device, and enough slack is taken in the hoisting rope to insure that the cage will drop to the 12- by 12-inch timbers if the safety catches fail. When these arrangements have been completed, the tripping device is sprung by means of a hand line, which is passed through a set of pulley blocks, and the freed cage drops until the safety catches function. The chain used for this test has seven special links for attaching to the hook of the tripping device, so that seven tests may be made with the safety catches engaging in a different place in each test for each change of the renewable sections of the wooden cage guides.

The same general procedure is followed when testing the safety catches on the cage at the ventilation shaft, but the tripping device used (fig. 11) is sprung easily with a hand line.

Mine L

The vertical shaft at mine L is about 2,000 feet deep, and daily production is about 800 long tons of iron ore, with 75 men working underground. A cage is used to transport men and supplies.

When the safety catches are to be tested, the cage is hoisted into the head frame, and two 12- by 12-inch timbers are placed across the shaft at the collar. The cage is lowered onto the timber, and 12 to 15 feet of slack is pulled in the hoisting rope between the hoist house and the head frame. A testing device is clamped to the hoisting rope so as to form a loop with the slack in the rope, and the cage is hoisted a few feet above the timbers that block the shaft. When these arrangements have been completed, the testing device is sprung, and the freed cage drops until the safety catches function.

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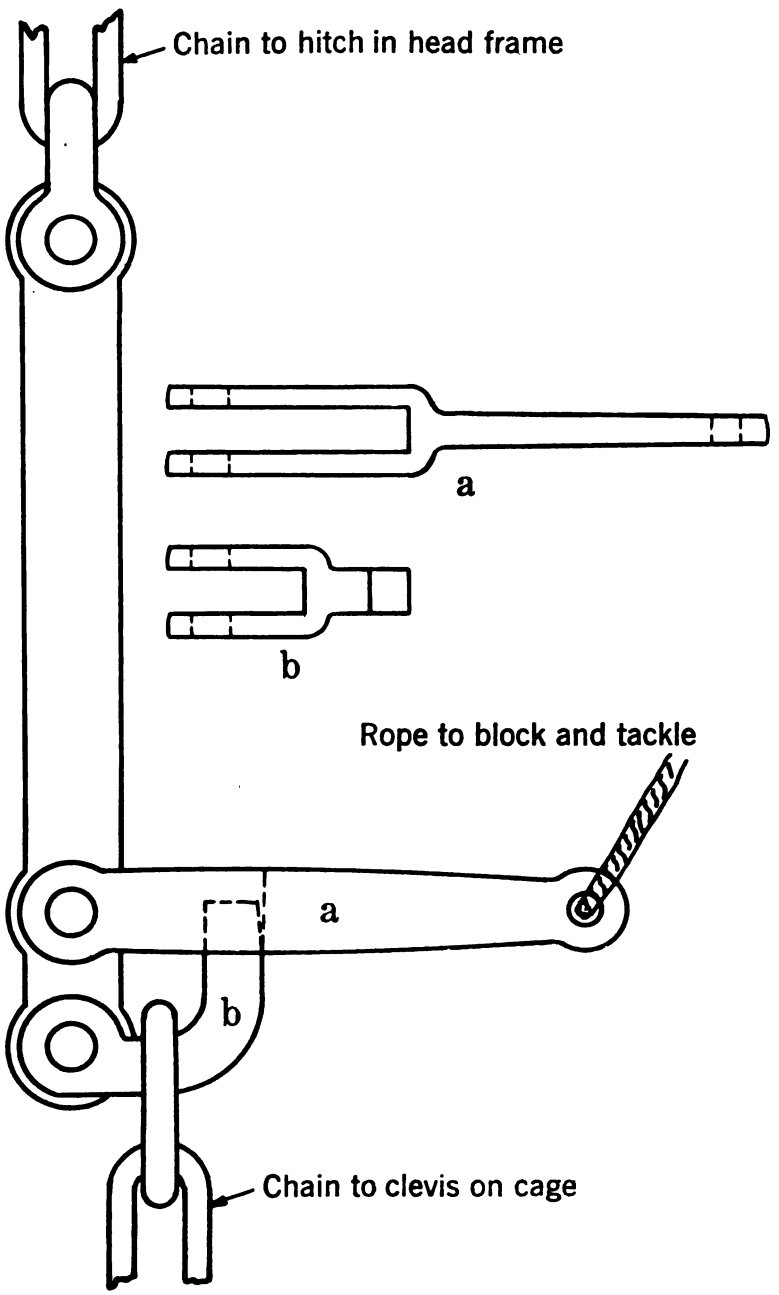

FIGURE 10.- Tripping device for testing safety catches—mine K.

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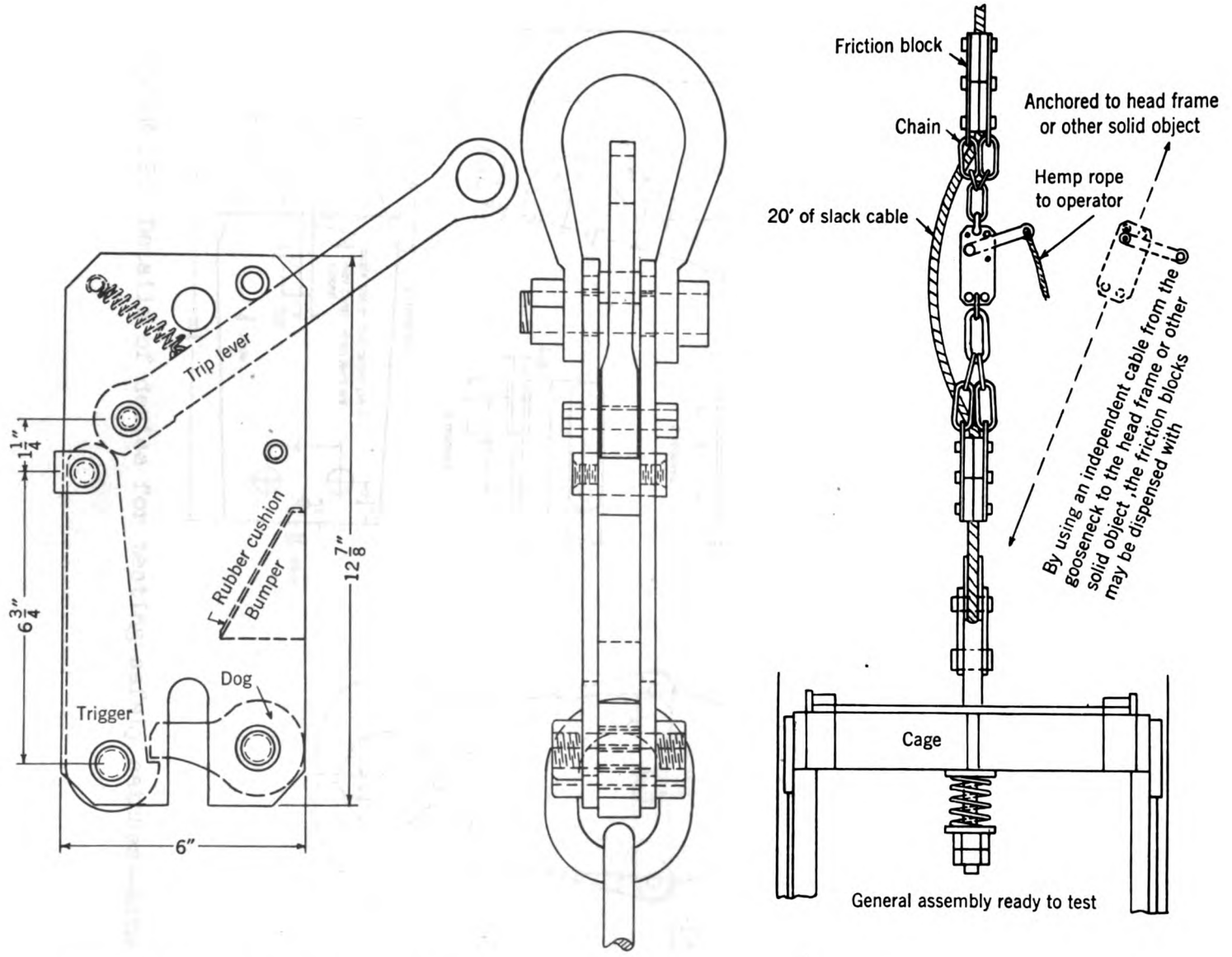

FIGURE 11.- General arrangements and details of device for testing safety catches—mine K.

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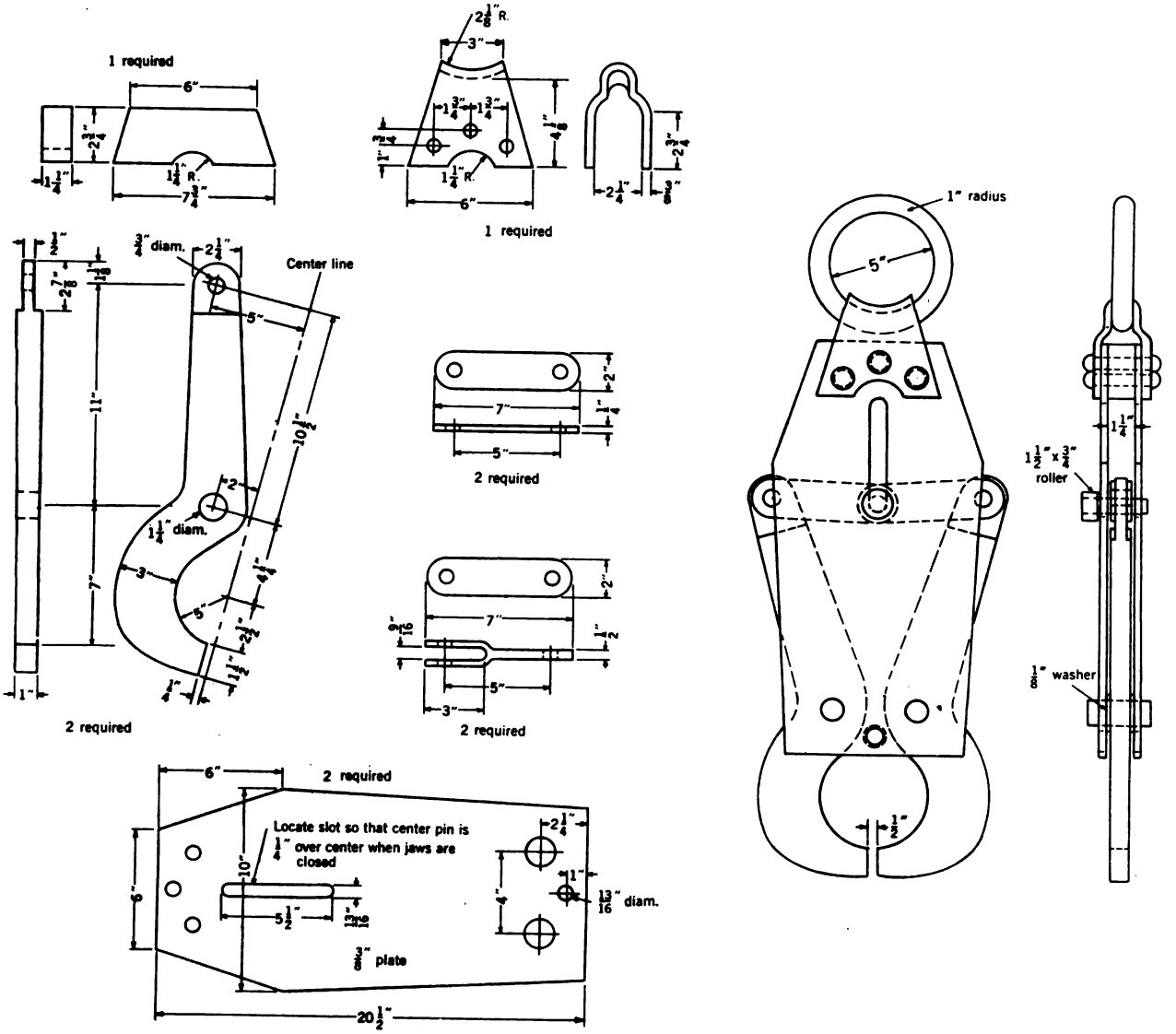

FIGURE 12.- Details of device for testing safety catches—mine M.

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Mine M

The shaft at mine M is about 1,900 feet deep. Eighty men are employed underground, and an output of about 700 long tons of iron ore is produced daily. A cage is used to transport men and supplies.

When the safety catches are to be tested, the cage is hoisted into the head frame, and two 12- by 12-inch timbers are placed across the shaft at the collar. A testing device in the head frame is swung out into the cageway and is attached to the top of the cage. The cage is lowered until it is suspended from the testing device, and slack is taken in the hoisting rope. When arrangements are complete, the tripping device (fig. 12) is sprung by means of a rope attached to the toggle joint, and the freed cage drops until the safety catches function.

CONCLUSIONS

The cages used in the shafts at the iron mines in the Lake Superior district are equipped with safety catches that appear to be adequate and efficient; however, this is an assumption, because exhaustive inquiry has not disclosed a single cage accident that involved use of the safety catches. This leads to the conclusion that inspection and care of the hoisting ropes on the cages are sufficient to prevent rope failures when cages are in operation.

When safety catches are working properly, they function immediately if the tension on the hoisting rope or drawbar of the cage is released, because the maximum drop recorded in the tests is 5 inches, and the average drop is about 2-1/2 inches.

The drop tests, as conducted, are believed to be adequate and sufficient to insure the proper functioning of the safety catches in an emergency.

Periodic inspection of safety catches may be too casual or infrequent at some mines, because instances were cited (but could not be confirmed) of safety catches that were found to be obstructed and did not function when tested. Two instances were cited where the cage dropped to the bottom of the shaft during tests because the shafts had not been covered at the collar.

The safety catches appear to function efficiently both when the cage is empty and when it carries a normal dead load.

A more severe test would be to release the safety catches while the cage is moving down the shaft at its maximum normal speed with a normal dead load, but as the only purpose of such a test would be to determine the strength of the safety catches and wooden cage guides, it is believed unwarranted in view of cage-accident history in the district.

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RECOMMENDATIONS

All cages on which men are hoisted or lowered should be equipped with safety catches.

The safety-catch mechanism should be inspected frequently, probably daily, for accumulations of foreign matter that might interfere with their action in an emergency.

The safety catches should be tested at least monthly by the slack-rope drop-test or similar method.

These tests should be made from a normal operating position without disturbing the safety catches or their actuating mechanism before the cage is dropped.

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